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Sleep patterns of offshore day-workers in relation to overtime work and age

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ABSTRACT

In addition to long contractual hours during offshore weeks (14×12 h shifts), many personnel on North Sea oil/gas installations also work overtime, but little is known about the implications of overtime for sleep patterns offshore. In this study, the additive and interactive effects of overtime and age were analysed as predictors of sleep duration and sleep quality among offshore day-workers ($N = 551$), 54% of whom reported overtime. Sleep duration and quality were impaired among personnel who worked overtime, relative to those who worked only standard shifts; there was also an inverse dose–response relationship between overtime hours and sleep duration. Although the sleep measures were more favourable during shore leave than during offshore weeks, there was little evidence of compensatory sleep patterns. These findings are discussed with reference to known performance and health effects of short sleep hours; formal guidance on overtime work offshore is noted; and methodological issues are considered.

1. Introduction

Long work hours have been implicated in a range of physical and mental health impairments, including hypertension, cardiovascular disease, obesity, and depression (e.g. Bannai and Tamakoshi, 2014; Kim et al., 2013; Landsbergis et al., 2013; Solovieva et al., 2013). Decrements in cognitive performance have also been linked to long work hours (Proctor et al., 1996; Virtanen et al., 2009a,b). At an organizational level, long hours are associated with low productivity and poor work performance (Holden et al., 2010; Rosekind et al., 2010), high turnover rates (Steinmetz et al., 2014), sickness absence (Lallukka et al., 2014), and increased risks of accidents and injuries (Dong, 2005; Uehli et al., 2014). In seeking to understand the pathways by which long work hours are associated with these adverse individual and organizational outcomes, sleep has been a central focus of attention.

Thus, a review of earlier work, van der Hulst (2003) identified consistent links between long work hours and sleep disturbances, including short sleep duration. More recently, prospective and cross-sectional studies have provided further evidence that long hours are a risk factor for short sleep duration (Artazcoz et al., 2009; Magee et al., 2009; Ohtsu et al., 2013; Swanson et al., 2011) and other sleep impairments (Nakashima et al., 2011; Virtanen et al., 2009a,b). For instance, in a prospective study of UK civil servants, working >55 h per week (relative to 35–40 h week) predicted sleep disturbances among those free from sleep problems at baseline (Virtanen et al., 2009a,b); the associations took a linear dose–response form. Nakashima et al. (2011) reported similar findings, again including a dose–response relationship between work hours and short sleep duration.

Long work hours (60 h/week) have also been found to predict sleep impairment not only during work days but also during non-work days (Ohtsu et al., 2013; Swanson et al., 2011), although some evidence suggests that extended recovery sleep follows long hours of work (e.g. Hirsch Allen et al., 2014). Other evidence, in turn, links sleep impairments, particularly short sleep hours, to severe sleepiness at work (Son et al., 2008), occupational injuries (Salminen et al., 2010), sickness absence (Lallukka et al., 2014), performance impairment and increased risk of errors (Rogers et al., 2004; Williamson and Feyer, 2000), and depression (for a review, see, Weich, 2010).

Thus, sleep disturbances associated with long work hours and overtime are a potential risk factor not only for health problems, but also for performance decrements, accidents and injuries, and

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other organizationally-relevant outcomes. Much of the existing research in this area derives from large-scale studies covering a variety of socio-economic groups, occupations, and work rosters. These studies typically consider long work hours and sleep disturbance in the context of a regular work week of 30–40 h, and examine the effects of varying amounts of overtime, which may increase the total hours worked to 55 h per week or more (e.g. Artazcoz et al., 2009; Swanson et al., 2011; Virtanen et al., 2009a,b). In contrast, little is known about the impact on sleep of overtime carried out during extended work rosters in which 12-h shifts are worked for two or more weeks, alternating with periods of extended leave; when these long contractual hours are combined with overtime, work hours may be in excess of 100 h/week.

Research into extended work patterns has been carried out in several different industries, including remote mining (Di Milia and Bowden 2007; Muller et al., 2008), offshore oil/gas (Nielsen et al., 2013; Parkes, 2012; Waage et al., 2012), seafaring (e.g. Bridger et al., 2010; Hansen and Holmen, 2011), and remote construction (Forberg et al., 2010). Personnel employed in these industries are typically exposed not only to long work hours but also to a range of occupational stressors, including demanding physical work, potentially hazardous processes, safety-critical tasks, and crowded living space; in these circumstances, it is particularly important to understand the impact of overtime work as evidence suggests that physical and psychosocial stressors at work may combine with long work hours to predict need for recovery (Jansen et al., 2003).

Existing research into extended work schedules and sleep in industries that operate in remote locations tends to focus on standard contractual hours and, in particular, on day/night shift rotation (e.g. Menezes et al., 2004; Persson et al., 2006; Saksvik et al., 2011a). Thus, the issue of overtime among day-work personnel has been largely overlooked by researchers in these industries, although in the North Sea oil/gas industry the need for research into overtime work and its impact on sleep has long been recognized. In particular, Härmä et al. (2008) noted that overtime worked offshore merits research not only because it extends the 84-h contractual week, but it also because it increases exposure to harmful chemicals, and other potential health hazards. The present study represents an initial attempt to evaluate the impact of overtime work on the sleep patterns of offshore day-shift personnel.

1.1. Present study

The present study was carried out on North Sea oil/gas installations; in this environment, the standard work pattern is 14 consecutive days of 12-h shifts, alternating with a similar period of shore leave. In addition to these contractual work hours, overtime is not unusual (Lodden, 2000). Moreover, the offshore environment exposes personnel to challenging physical and psychosocial conditions, including potentially hazardous processes, constrained working and living space, and shared cabin accommodation. The main aim of the present study was to examine the role of overtime in relation to the duration and quality of sleep among North Sea personnel during offshore weeks and, for comparison, during leave weeks. The data analysis was restricted to permanent day-shift workers (who are responsible for the majority of offshore overtime work) in order to avoid the possible confounding effects of circadian disruption associated with day/night shift rotation.

In the analysis of sleep patterns, the study also took into account individual differences in age. Higher age is known to be associated with greater risk of sleep impairment (e.g. Marquié et al., 2012; Ohayon et al., 2004); in the present study, sleep disturbances associated with age were of particular interest in view of their implications for health and safety offshore. On the basis of the onshore research findings outlined above, it was predicted that overtime hours would be inversely associated with sleep quality and duration and, more specifically, that there would be a negative dose–response relationship between overtime hours and sleep duration during offshore weeks. It was also expected that age would be inversely related, either additively or interactively with overtime hours, to sleep duration and/or sleep quality during work weeks.

2. Methods and materials

2.1. Participants and procedure

Data were collected from personnel working on 12 North Sea oil/gas production installations. Researchers visited each installation for 2–3 days to distribute the survey materials; all personnel on board were invited to participate. Two visits were made to each installation to allow crew members on leave during the initial visit to take part. During these visits, researchers outlined the nature of the research to potential participants (emphasising that participation was voluntary and that all data would be treated as confidential) and responded to questions. Questionnaires were identified only by ID numbers. Completed questionnaires were returned in individual sealed envelopes before the researchers left the installation. Further details of the data collection are given by Parkes (in press). In total, 1130 personnel (85% response rate) returned completed questionnaires. Exclusion of personnel who did not work permanent day shifts, personnel who had been working on the installation for less than 2 months, and females (who made up <3% of personnel on board), left 572 personnel in the sample. After listwise deletion of missing data, the analysis sample consisted of 551 male day-shift personnel.

2.2. Measures

The following measures (obtained as part of a wider survey of offshore work conditions, health and safety) were included in the present analysis.

2.2.1. Age

The mean age of participants was 40.2 (SD 8.9) y, range 20–62 y.

2.2.2. Overtime

Participants recorded how many hours in excess of 12 h shifts they normally worked during a week offshore. 46% ($n = 254$) reported that they worked no overtime; among the remaining 54% ($n = 297$), the mean overtime was 16.0 (SD 7.6) h per week (range 2–42 h).

2.2.3. Control variables

Installation and job category were included in the analysis model to control for environmental and task-related differences. Anxiety was also included as a control variable to take into account individual differences in shift work tolerance (Tamagawa et al., 2007), and to avoid possible confounding with overtime in predicting sleep. *Installations.* Across the 12 installations in the study, the number of participants included in the present analysis ranged from 19 to 84; the mean was 46, SD 25. *Job category.* Seven job categories were identified: maintenance/technical ($n = 231$); management ($n = 98$); production ($n = 16$); catering (48); administration/clerical ($n = 55$); construction/deck/marine ($n = 81$); drill crew ($n = 22$). *Anxiety* was assessed by the General Health Questionnaire (Goldberg and Hillier, 1979) seven-item anxiety scale. Items were scored on a 0–3 rating scale. The mean score was 4.10 (SD 3.63), range 0–21. Coefficient alpha was .83.

2.2.4. Sleep measures

Sleep duration and sleep quality were assessed for day shifts (DS) and leave weeks (LS). The questions: '*When you are working day shifts, how many hours do you usually sleep during the off-duty period?*' and '*How well do you usually sleep during this period?*' were used to assess DS sleep. The latter question assessed sleep quality on a 7-point scale (*0 = 'Very badly'* to *6 = 'Very well'*). LS sleep was assessed with the questions, '*When you are on leave, how many hours do you usually sleep at night?*' and *'How well do you usually sleep when on leave?'* using the same 7-point response scale.

2.3. Statistical analysis

A mixed-model ANCOVA (GLM Repeated Measures procedure, SPSS-19) analysis was used in which the repeated-measures factor, designated Phase, represented the DS and LS sleep outcome measures. Age (standardized to facilitate testing interactions) was entered as a continuous variable. Type of installation, job category, and anxiety were included as control variables. At the within-subjects level, interactions of Phase with the independent variables were evaluated. Three-way interactions of Phase with overtime and age were tested, but they were not retained in the model if non-significant. The 'between-subjects' level of analysis was only interpreted for variables that did not interact significantly with Phase.

2.3.1. Coding of overtime data

Following the approach of Cohen and Cohen (1983,p.286), sometimes referred to as the 'missing data dichotomy' method, two variables were used to code overtime. First, a dichotomous variable (designated 'Overtime01') distinguished those who worked 'no overtime' (coded 0) from those who worked at least 1 h per week overtime (coded 1). The second variable, 'Overtime Hours', represented the duration of weekly overtime reported by those who did overtime. For this variable, the mean value of overtime hours for participants who reported overtime was substituted for the 'missing' overtime data in the group that did no overtime. This method allows the separate effects of overtime versus no overtime, and duration of overtime, to be evaluated in a single analysis, provided that the 'Overtime Hours' variable is only interpreted when the dichotomous 'Overtime01' variable is also in the simultaneous analysis model.

3. Results

3.1. Means, SD, and inter-correlations of the study variables

The inter-correlations among the independent variables, Age, Overtime01, and Overtime Hours, and the DS and LS sleep duration and sleep quality measures are shown in Table 1. Overall, 54% of the participants reported some overtime work; among these personnel, the mean duration of overtime was 16 h/per week (range 2–42 h/week). The mean age of personnel was significantly higher in the overtime group (41.9 y, SD 8.0) than among those who did not work overtime (38.2 y, SD 9.6) ($t = 4.83$; df 1549; $p < .001$).

Mean sleep duration during offshore work weeks was 1 h per day less than during leave weeks, and sleep quality showed a corresponding difference. DS (but not LS) sleep duration was negatively correlated with the dichotomous variable, Overtime01, representing overtime (coded 1) versus no overtime (coded 0). Among personnel who did overtime work, Overtime Hours were inversely correlated with DS sleep duration but unrelated to the sleep quality measures. Age was inversely related to DS and LS sleep duration measures, but not to sleep quality. The correlations among sleep measures, although mostly significant, were small to moderate in magnitude.

Table 1
Means, standard deviations and inter-correlations among the study variables.

Measure		Mean	SD	Age	Anxiety	Sleep duration		Sleep quality	
						DS	LS	DS	LS
Overtime work (yes/no)[a]		.54	–	.20**	.05	−.29**	.00	−.14**	−.04
Overtime hours (h/week)[b]		16.01	7.62	.05	.10	−.26**	.06	−.02	.04
Age		40.19	8.94	–	−.05	−.09*	−.16**	.02	.06
Anxiety		4.09	3.63		–	−.18**	−.03	−.37**	−.23**
Sleep duration (h/day)	DS	6.74	0.87			–	.27**	.25**	.12**
	LS	7.75	1.00				–	−.01	.25**
Sleep quality	DS	3.92	1.29					–	.35**
	LS	4.83	1.11						–

DS = Day shifts, LS = Leave weeks.
$N = 551$, ** $p < .01$; * $p < .05$.
[a] Overtime work: 0 = no, 1 = yes.
[b] $N = 551$, except for overtime hours and correlations with overtime hours which relate only to participants who reported overtime ($n = 275$).

Installation and job type, treated as control variables in the multivariate analyses, differed significantly in the proportion of personnel reporting overtime work. Across the 12 installations, the proportions ranged from 21.3% to 94.7%, while, across job categories, the range was from 37.5% (catering staff) to 89.8% (managers). There were also significant differences across installations and job types in the number of overtime hours worked; excluding those who did no overtime, the mean durations of weekly overtime ranged from 9.6 h to 18.8 h across installations, and from 13.9 h (catering staff) – 19.6 h (drilling crew) across job categories. Anxiety, the third control variable, was negatively related to DS sleep duration and to both sleep quality measures.

3.2. Analysis of sleep measures in relation to overtime and age

The results of the mixed-model ANCOVA analyses are shown in Table 2. In these analyses, the repeated-measures factor 'Phase' represented the DS and LS sleep outcomes. The independent variables were Overtime, coded as two variables, Overtime01 and Overtime Hours (see the 'Statistical analysis' section) and the continuous (standardized) Age measure.

3.2.1. Sleep duration

At the 'within-subjects' level, Phase showed a highly significant overall effect; LS sleep duration was significantly longer than DS sleep duration. In addition, as outlined below, there were significant interactions between Phase and each of the two variables representing overtime. There was also a significant Phase × Age interaction. However, there were no significant Age × Overtime01, or Age × Overtime Hours, interactions at either level of analysis; these terms were therefore not included in the model.

3.2.1.1. Overtime. The negative association of the dichotomous variable, Overtime01, with sleep duration differed significantly for DS and LS sleep; similarly, the association between Overtime Hours and sleep duration also differed for DS and LS sleep. Thus, DS sleep duration was significantly greater for personnel who did not work overtime (reference condition) than for those that did work overtime ($B = -.53$, $t = 6.53$, $p < .001$). The adjusted mean values were 7.07 h (CI 6.93–7.21) for the no overtime group, and 6.54 h (CI 6.42–6.66) for the overtime group. In addition, the continuous variable, Overtime Hours was inversely and linearly related to DS

Table 2
Repeated-measures analyses of variance predicting sleep duration and sleep quality during day-shifts offshore and leave weeks.

	Sleep duration				Sleep quality			
	F	df	*p*	Partial eta^2	*F*	df	*p*	Partial eta^2
Within subjects								
Phase (*P*)	40.61	1,529	<.001	.071	27.24	1,529	<.001	.049
P × Overtime01	28.29	1,529	<.001	.051	3.11	1,529	[<.10]	.006
P × Overtime Hours[a]	11.89	1,529	.001	.022	–	–	–	–
P × Age	9.13	1,529	<.01	.017	<1	1,529	*ns*	.002
P × Anxiety	2.84	1,529	*ns*	.005	15.51	1,529	<.001	.028
P × Installation	1.69	11,529	*ns*	.034	<1	11,529	*ns*	.013
P × Job category	1.08	6,529	*ns*	.012	<1	6,529	*ns*	.009
P × Age × Overtime01[b]	–	–	–	–	7.47	1,529	<.01	.014
Between subjects								
Overtime01	11.12	1,529	.001	.021	4.43	1,529	<.05	.008
Overtime Hours	3.21	1,529	*ns*	.006	–	–	–	–
Age	5.28	1,529	<.025	.010	2.38	1,529	*ns*	.004
Anxiety	9.41	1,529	<.01	.017	80.91	1,529	<.001	.133
Installation	1.85	11,529	<.05	.037	<1	11,529	*ns*	.010
Job category	1.38	6,529	*ns*	.015	<1	6,529	*ns*	.007
Age × Overtime01	–	–	–	–	2.61	1,529	*ns*	.005

[a] *Overtime Hours*, and *P* × *Overtime Hours*, were non-significant in the sleep quality analysis.
[b] *Phase* × *Age* × *Overtime01*, and *Age* × *Overtime01*, were non-significant in the sleep duration analysis.

sleep duration ($B = -.20$, $t = -3.90$, $p < .001$). In contrast, neither of the overtime variables was a significant predictor of LS sleep duration ($t < 1$ in each case). These results are shown graphically in Figs. 1 and 2.

3.2.1.2. Age. The Phase × age interaction was significant; as shown in Fig. 3, DS sleep duration was unrelated to age ($B = -.01$, $t < 1$, ns) whereas LS sleep duration showed a significant negative association ($B = -.15$, $t = -3.34$, $p < .001$). Throughout the age range, LS sleep duration was greater than DS sleep duration, but the difference between the LS and DS measures decreased with age.

3.2.2. Sleep quality

3.2.2.1. Overtime. For the sleep quality measure, the variable Overtime Hours showed no significant results at either level of analysis; this term was therefore dropped from the model. In contrast, the dichotomous Overtime01 variable was significant overall, but the interaction Phase × Overtime01 only reached marginal significance. Adjusted sleep quality was significantly higher among personnel who did not work overtime (4.49, CI 4.33–4.65) than among those who did work overtime (4.30, CI 4.16–4.44). Also, LS sleep quality (4.81, CI 4.67–4.95) was significantly higher than DS sleep quality (3.98, CI 3.82–4.13). However, as shown in Table 2, the higher-order interaction, Phase × Overtime01 × Age was significant, indicating a complex pattern of findings in which Overtime and Age interactively predicted DS and LS sleep.

This interaction was further examined by carrying out separate analyses for the DS and LS measures. For the DS measure, there was a main effect of Overtime01, but the Overtime01 × Age interaction was non-significant; thus, irrespective of age, personnel who worked no overtime reported higher DS sleep quality than those who did work overtime ($F = 6.75$, df 1,529, $p < .01$). For LS sleep quality, the Overtime01 × Age interaction was significant ($F = 9.57$, df 1,529, $p < .01$). Age was a significant and positive predictor of LS sleep quality among personnel who worked overtime ($B = .246$, $t = 3.31$, $p < .001$), but it was non-significant for those who did no overtime ($B = -.057$, $t < 1$, ns). Of the control variables, only Anxiety predicted sleep quality; the association was negative, and stronger for DS sleep quality than for LS sleep quality.

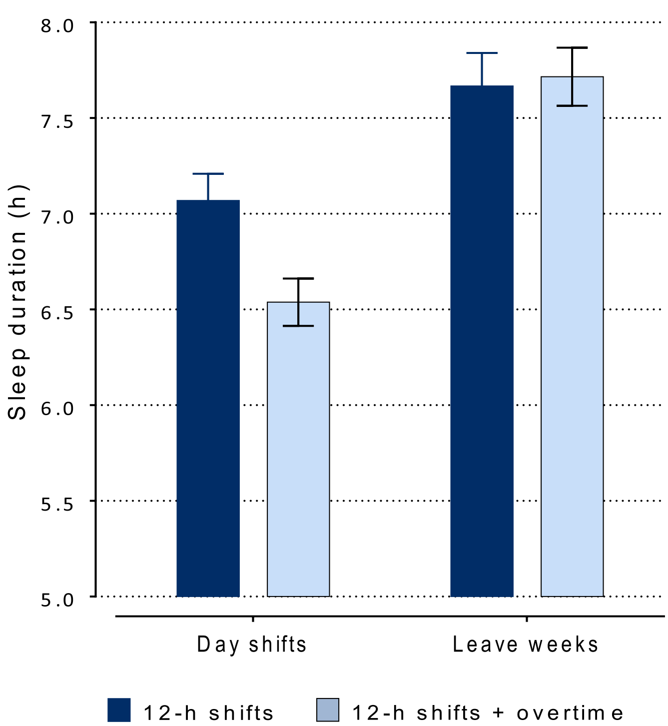

Fig. 1. Sleep duration for day shifts and leave weeks in relation to overtime work.

4. Discussion and conclusions

The North Sea oil/gas industry exposes personnel not only to a challenging combination of physical and psychosocial demands rarely found in onshore industry, but also to very long work hours. Thus, more than half the present sample of offshore day-workers reported overtime in addition to the 84-h contractual work week and, as compared with those who did no overtime, the overtime group was significantly older, and therefore potentially more vulnerable to sleep disturbances (e.g. Ohayon et al., 2004). The main aim of the present study was to evaluate the extent to which overtime, together with age, predicted sleep in the offshore environment, controlling for anxiety and for differences across installations and job categories. In summary, the results showed that overtime work was associated with overall shorter sleep duration and poorer sleep quality during offshore weeks, but was unrelated to sleep during leave weeks; also, consistent with epidemiological

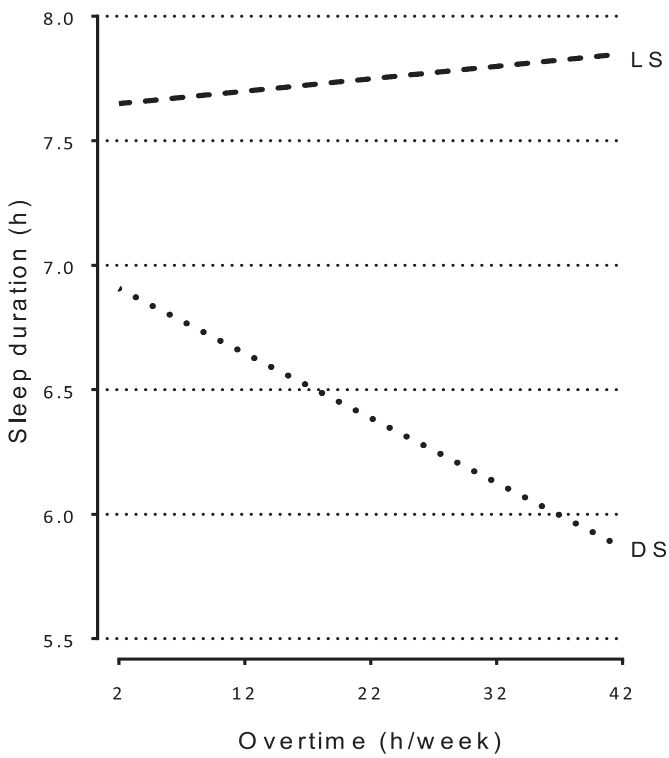

Fig. 2. Sleep duration in relation to overtime hours for day-shifts (DS) and leave weeks (LS).

findings (e.g. Virtanen et al., 2009a,b), the association between sleep duration and overtime hours showed a dose–response relationship.

Before considering these specific findings in more detail, it is important to set the issue of offshore work hours and sleep in a wider context. In particular, the duration of the standard offshore work week is more than twice the normal onshore week. Onshore, total work hours (i.e. contractual hours plus overtime) rarely reach the regular 84-h week that applies offshore (e.g. Nakashima et al., 2011; Swanson et al., 2011; Virtanen et al., 2009a,b), and the addition of offshore overtime makes the discrepancy even greater. However, unlike onshore work, offshore schedules also include extended periods of shore leave. These breaks provide opportunities for compensatory rest and recovery from fatigue and sleep debt arising from the long hours worked offshore. None the less, relative to a normal 5-day, 35–40 h week, the extended schedule of 14 × 12 h shifts, together with demanding work tasks, crowded living space, and shared cabin accommodation, would be expected to impact adversely on sleep and overnight recovery during offshore weeks.

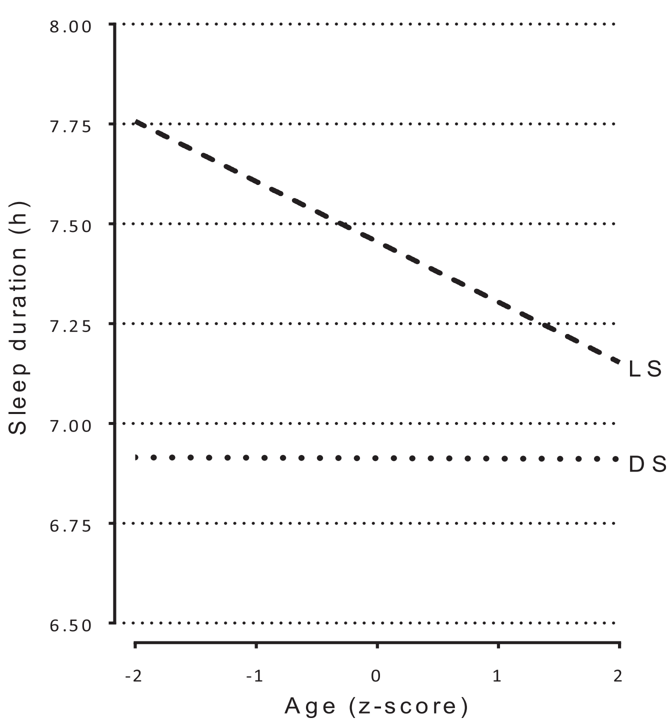

Fig. 3. Sleep duration in relation to age for day shifts (DS) and leave weeks (LS).

In the present sample, the overall mean DS and LS sleep durations were 6.74 h and 7.75 h per night, respectively, which correspond closely to the sleep durations (6.8 h, workdays; 7.5 h, non-workdays) reported for a national sample of US workers (Swanson et al., 2011). Thus, irrespective of the very different work hours and living conditions, there appears to be little difference in mean sleep duration between the present offshore workers and onshore workers in a range of occupations. One possible explanation is that, although offshore personnel work long work hours in a demanding environment, other aspects of offshore employment (e.g. no daily commuting, no domestic or child-care responsibilities during off-shift hours, provision of regular meals, and cabins with no natural light exposure) may be favourable to sleep, and thus serve to offset the negative effects of extended work weeks, early day-shift start times, and crowded offshore living conditions. Also, offshore employment requires individuals to meet stringent medical standards (UK Oil & Gas, 2008), and the favourable health status of offshore personnel may partially mitigate any adverse environmental effects on sleep.

4.1. *Overtime*

Overall, overtime was associated with impaired sleep during offshore weeks relative to standard 12-h shifts. Also, both sleep duration and sleep quality were significantly more favourable during leave weeks than during work weeks, but there was no evidence of longer compensatory LS sleep among overtime workers relative to those who worked only standard shifts.

4.1.1. *Overtime and sleep duration*

As compared with personnel who worked no overtime, those who did work overtime reported significantly shorter DS sleep duration; moreover, DS sleep duration was also inversely related to the number of overtime hours worked per week. Thus, in the overtime group, DS sleep duration decreased in a linear, dose–response manner from 6.90 h per night for the lowest level of overtime (2 h per week) to 5.85 h per night for those working the longest overtime (42 h/week), compared with 7.07 h per night for those who did no overtime. The dose–response nature of this relationship could imply a causal effect, although the cross-sectional nature of the present data does not allow definite causal inferences.

Evidence from epidemiological studies suggests that the association between sleep duration and health outcomes takes a curvilinear form in which habitual sleep durations outside the range of approximately 6–9 h per night are associated with adverse health consequences, including mortality (e.g. Amagai et al., 2004); within this range, sleep durations of 7–8 h are usually found to be optimal (Hublin et al., 2007; Lallukka et al., 2014). In the present study, at the highest levels of overtime (>35 h/week), adjusted

sleep hours fell below the 6 h/day level shown to be the minimum sleep required to prevent significant daytime performance impairment (Van Dongen et al., 2003). Only a small proportion of personnel reported these high levels of overtime, but personnel who reported ≥18 h overtime per week made up 20.5% of the total sample, and 38.0% of the overtime group; on average this level of overtime was associated with 6.5 h sleep per night, notably less than the 7–8 h sleep advocated.

Good practice offshore, as set out by the UK Health and Safety Executive (HSE) (2009), recommends that there should be an absolute limit of 14 h work in any one shift (i.e. a 12-h shift plus 2 h overtime), that overtime on consecutive shifts should be avoided, and that normal production operations should not rely on overtime work. The present study suggests that these guidelines would allow an average sleep duration of approximately 7 h/night among those working 7 h/week overtime (equivalent to 2 h per shift on alternate shifts), thus just reaching the recommended level of 7–8 h. Whilst it was not possible to determine exactly how many of those working overtime were exceeding the HSE guidance levels, 84% of the overtime group reported >7 h/week overtime.

These findings imply that, for a large majority of day-shift personnel working overtime, the HSE guidance was not being followed. The difficulty of recruiting suitable skilled personnel for offshore work, especially at senior levels, may partially explain the high levels of overtime observed in the present study. Moreover, personnel working offshore regard operational demands as their primary concern, especially in safety-critical areas, and consequently allow work hours to extend beyond standard 12-h shifts when necessary to meet these demands. The need for sleep, rest and recovery is given a lower priority, with the result that sleep hours are limited to the time that remains after work tasks and necessary off-shift activities (including meals) are finished. Whilst HSE guidance relating to overtime is not mandatory, the present study suggests that there is a need to monitor overtime hours more closely to ensure that offshore personnel do not undertake overtime at a level which prevents them from obtaining adequate sleep. More generally, there is also a need to determine whether overtime carried out on offshore installations varies significantly across operating companies and geographical sectors in the offshore industry as a whole, and to identify the occupational groups at greatest risk of excessive overtime.

4.1.2. Overtime and sleep quality

DS sleep quality was significantly poorer among personnel who worked overtime relative to those who did no overtime, but there was no evidence of a dose–response relationship between Overtime Hours and sleep quality. Associations between overtime work and impaired sleep quality have been reported (e.g. Nakashima et al., 2011), and the present results could reflect a direct effect, or one mediated by, for instance, work-related rumination (Takano et al., 2012). However, although anxiety was included in the analysis model as a control variable, it is also possible that one or more ‘third factors’ are implicated. For instance, there is evidence that personality traits predict a variety of sleep measures (Saksvik et al., 2011b); some aspects of personality (e.g. perfectionism, obsessionality, or workaholism) may also be associated with a tendency to work beyond normal hours, thus potentially inflating the negative association between overtime and sleep quality.

4.2. Age

Age, and its possible implications for health and safety offshore, has long been an issue of concern to the North Sea industry which has traditionally had a relatively high age profile (Bjerkebaek, 2002). However, increased recruitment of younger workers in recent years has stabilised the average age of the UK offshore workforce to 40–41 years, although in some key occupations, the mean age tends to be higher (UK Oil & Gas, 2012). In particular, personnel in management positions who have responsibility for the safe operation of the installation are likely to be older than those in less senior roles. Thus, their ability to monitor day-to-day production, to evaluate information and make decisions, to communicate clearly, and to respond promptly to incidents and operational emergencies, is critically important to the safety of all on board; for these personnel, obtaining adequate sleep is essential to ensure effective performance of these cognitive tasks.

4.2.1. Age and sleep duration

The association between age and sleep duration differed for DS and LS sleep; DS sleep duration was effectively constant irrespective of age, but LS sleep duration was significantly negatively related to age. The LS finding is consistent with evidence of greater sleep disturbance among older workers (e.g. Marquié et al., 2012; Ohayon et al., 2004). However, the finding that DS sleep duration was unrelated to age suggests that adapting to offshore conditions (e.g. early morning shift starts, noise disturbance at night, and shared cabins) may be more detrimental to the sleep of younger workers than to their older and more experienced counterparts, thus moderating the typical pattern of decreasing sleep duration with increasing age. It is also likely that older personnel who have difficulty in obtaining adequate sleep offshore would be more likely to move to onshore employment, thus leaving a ‘survivor’ population, in which the expected pattern of shorter sleep with increasing age is not apparent, or is even reversed (Marquié et al., 2012). Among Norwegian offshore day-shift workers, Waage et al. (2010) reported sleep durations of about 7.1 h per day, but with an upward trend across the age range, again suggesting that the normal decrease in sleep duration with age is modified by the offshore environment and/or by selective withdrawal from the offshore workforce.

Taken together, the findings for age and overtime suggest that older individuals who work moderate or high levels of overtime are at particular risk of sleep loss; thus, these personnel had shorter DS sleep duration during offshore weeks (compared to those doing little or no overtime), and shorter compensatory LS sleep during leave weeks (compared to younger personnel). As noted above, older offshore personnel are more likely to have responsibility for safety-critical activities, and it may therefore be difficult for them to avoid working overtime; in these circumstances, the present findings suggest that those concerned need to be aware of the possible impacts of high levels of overtime on sleep, and hence on performance and alertness, and of the importance of obtaining adequate rest and recovery during leave weeks.

4.2.2. Age and sleep quality

Although those who worked overtime showed lower DS sleep quality than those who did not, age was not a significant factor in either group. However, age was positively related to LS sleep quality among those who did overtime work. Bjerkebaek (2002) noted that older offshore workers have greater restitution need for undisturbed sleep, and are more susceptible to sleep disturbances from cabin noise or night-shift work activities. Thus, it is possible that the relatively high LS sleep quality of older personnel who worked overtime partially reflected greater fatigue and need for recovery.

4.3. Methodological issues

The main limitation of the present study was the use of cross-sectional, self-report data which precludes causal interpretation of the findings, and is potentially subject to the problems of

common method variance, although the factual nature of the independent variables analysed would tend to reduce generalised responses tendencies. A number of more specific aspects of methodology also merit comment. In particular, the study depended on subjective sleep reports; although the sleep durations reported here are generally in accordance with findings from offshore actigraphy (e.g. Saksvik et al., 2011a), other evidence suggests that self-reports of sleep tends to over-estimate data obtained from actigraphic recordings (Lauderdale et al., 2008). However, in the present study, over-estimation of sleep duration would be expected to produce conservative rather than exaggerated findings. Use of self-reported overtime hours represents a further limitation of the study.

It should also be noted that single items were used to assess DS and LS sleep quality; a multi-item scale would have been more reliable, but an over-long questionnaire could have reduced response rates. Also, both the DS and the LS sleep data were collected while participants were offshore, which could have biased the LS ratings; ideally, the LS sleep data should have been collected during leave weeks but this approach was precluded by the survey methodology used. However, the analyses focused not on individual outcome measures but on the patterns of DS and LS sleep in relation to overtime and age (i.e. on interactions of Phase with the independent variables, rather than on main effects). This ‘repeated-measures’ approach partially mitigates the problems of individual response tendencies and ‘third factor’ effects that may distort the findings of analyses using single outcome variables. Moreover, separate analyses of sleep duration and sleep quality demonstrated different patterns of results for these two measures. Thus, in terms of effect sizes, Phase and its interactions with the overtime measures jointly accounted for more variance in sleep duration than other independent variables; in contrast, for sleep quality, the main and interactive effects of Phase and Anxiety were the primary explanatory variables, while age and overtime played relatively minor roles.

Overall, in spite of its methodological limitations, the present study contributes to the existing literature in addressing an aspect of offshore working time about which little is currently known; in particular, the study serves to highlight concerns about overtime hours worked offshore and their association with impaired sleep. However, the cross-sectional, self-report methodology used does not permit causal interpretation of the findings, and future research in this area would benefit from more sophisticated assessment methods. In particular, use of actigraphic sleep recordings in combination with established self-report scales to assess sleep quality and duration, and independent measures of overtime hours (derived from formal company records), would eliminate some limitations of the present dataset. Moreover, although the present study took age into account, in future research, inclusion of personality trait measures known to be associated with sleep patterns, such as morningness/eveningness chronotype, neuroticism and/or extraversion (Saksvik et al., 2011b), would throw further light on the processes by which overtime impacts adversely on sleep, rest and recovery among offshore personnel.

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